POPULATION AND PRODUCTIVITY MONITORING OF MARBLED MURRELETS IN OREGON DURING 2009

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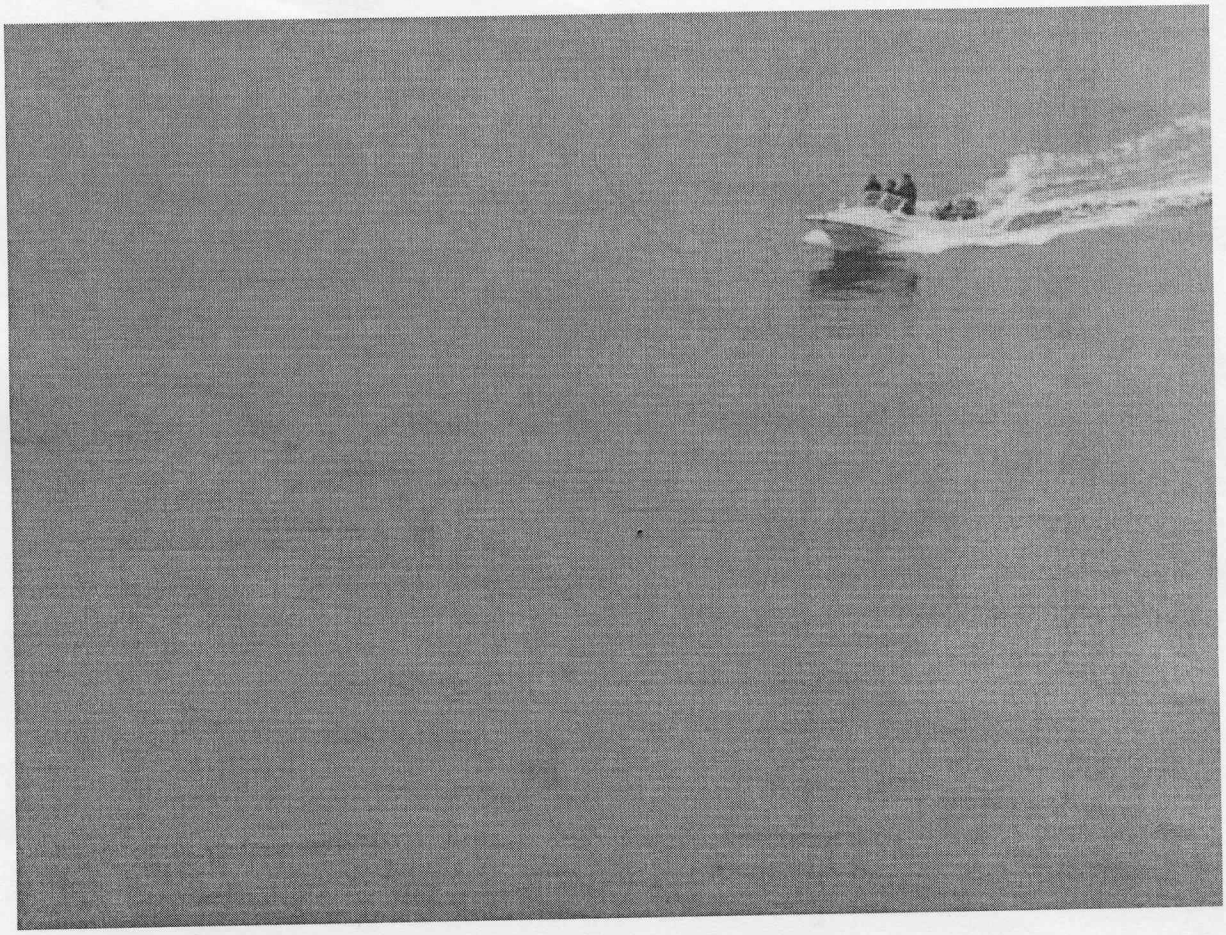

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SUMMARY

Vessel transect surveys of seabirds in coastal Oregon waters mid May to the end of July 2009 were used to estimate the population of Marbled Murrelets. This is the tenthyear of Marbled Murrelet population monitoring under the Northwest Forest Plan Effectiveness Monitoring Plan (NWFP). Transects followed a prescribed route through Primary Sampling Units (PSU) covering the Oregon coastal waters from 300 m to 5000 m offshore. We completed 31 population monitoring sample transects in the 17 contiguous PSU that comprise Conservation Zone 3, from the Columbia River to Coos Bay, and 14 transects in the northern portion of Conservation Zone 4, Coos Bay to Crescent City, California. The USFS Redwood Sciences Laboratories completed 3 additional PSU Samples in Oregon waters, and those data are included here.

The Zone 3 population estimate in 2009 was of 5,890 birds, with a confidence interval from 3,847 to 7,969 birds. The point estimate was 84% of the mean of the prior 9 years, and suggests a continuing slow decline in the population. The estimate for the Oregon portion of Zone 4 was of 2,806 birds, slightly above the 10 year average. Densities of murrelets within 1.2 km of shore from all transects were close to the 10 year average, with some high numbers encountered in late July.

The ratio of all aged murrelets at sea in Oregon after 20 July was of 36 fledglings to 757 older birds, or 4.5% fledglings. A confirmed fledgling seen on 30 May in southern Oregon was a record for the earliest known fledge date. Other alcid species appeared to have a fair to good year of productivity as well. Oceanographically, 2009 had regular pulses of upwelling which caused high primary productivity in Oregon waters, unaffected by developing ENSO conditions in the Eastern Tropical Pacific.

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DISCLAIMER

The analysis and interpretation of data presented in this report are the product of Crescent Coastal Research and do not necessarily represent the views of the U.S. Fish and Wildlife Service, the U.S. Forest Service, the Northwest Forest Plan at-sea effectiveness monitoring group, or other agencies.

INTRODUCTION

The Marbled Murrelet (*Brachyramphus marmoratus*) is a small diving seabird of the Alcid family which is on the Federally Threatened Species list, and is state listed as endangered or threatened in California, Oregon, and Washington (Nelson, 1997). Because their nests are dispersed and difficult to locate high in trees of mature coastal forests, most research on overall abundance and reproductive output is conducted at sea, where the birds are concentrated within a few km of shore on the open coast (Ralph and Miller 1995, Miller et al. 2006). Standardized boat transects to survey murrelets in the nearshore waters of the central Oregon coast from 1992 to 1999 produced evidence of a decline in numbers through this period (Strong 2003). In 2000 a new sampling design to monitor the murrelet population was initiated for all researchers in the Northwest Forest Plan area by the At-Sea Working Group under the Effectiveness Monitoring (EM) component of the Northwest Forest Plan (Madsen et al. 1999, Miller et al. 2006). This report summarizes population estimation and distribution results from the 2009 surveys in Oregon and compares these data with earlier assessments. The entirety of Marbled Murrelet Conservation Zone 3 (Columbia River to Coos Bay) and the Oregon portion of Zone 4 are included (see Fig. 1).

METHODS

Vessel Methods

Vessel surveys were made from a 7 m boat equipped with marine radio, compass, Global Positioning System receiver (GPS), and sonar depth finder, which also relayed sea surface temperature. Other equipment included binoculars, digital watches, and micro tape recorders for each person, maps covering planned transect lines, and a lazer range finder. The deck of the boat is about level with the waterline; so standing observer viewing height was about 2 m above water. The GPS was loaded with the randomly selected transect routes prior to each survey. Two observers and a vessel driver were on board for all transects. Each observer scanned a 90° arc between the bow and the beam continuously, only using binoculars to confirm identification or to observe plumage or behavior of murrelets. Search effort was directed primarily towards the bow quarters and within 50 m of the vessel, so that densities based on line and narrow strip transects will be at their most accurate (Buckland et al. 1993). All seabirds within 50 m of the boat and on the water were recorded. Pelicans and terns (aerial foragers) were also recorded when flying. All Marbled Murrelet detections at any distance were recorded with information on group size, side of vessel, estimated perpendicular distance from the transect line, behavior, molt class, and age. Marine mammals and boats were also recorded with an estimate of perpendicular distance from the transect line. Distance estimates were calibrated by running 10 replicates of estimated distance to small floating targets within the launch port on each survey day. All observers would estimate distance to the target, and then one would use the rangefinder and record the actual distance when the vessel was perpendicular to the target, and observers would adjust their estimates if necessary. Environmental parameters and observing conditions were monitored on all surveys. Data were recorded on cassette tapes and later transcribed and entered on computer.

The vessel driver maintained a speed of 10 knots, monitored the transect route, and watched for navigational hazards. The driver participated in searching for murrelets when not otherwise occupied. Transects were paused sometimes to rest, make observations, or for equipment

reasons, and resumed at the same location where they left off. A break from duties was taken at least every 3 hours.

Vessel Sampling
A thorough description of the population monitoring sampling design can be found in The Northwest Forest Plan - the First 10 Years (Miller et al. 2006) and Raphael et al. (2007). In short, the coast was divided into 20 km long Primary Sampling Units (PSU, see Fig. 1) and a transect was conducted through each PSU following a randomized transect route between 350 and 5000 m offshore (350 to 3000 m offshore in Zone 4). The objective in population monitoring under the Northwest Forest Plan was to complete 30 PSU samples within each Conservation Zone during the nesting period, from 15 May to 31 July. Surveys in the Oregon portion of Zone 4 (Coos Bay to California) were conducted cooperatively with RSL biologists.

Population estimates for Zones were generated by Jim Baldwin (USFS, NWFP at-sea working group) using line transect analysis with each PSU survey as a density sample. Analysis details for the NWFP population monitoring effort are contained in Raphael et al. (2007). The Zone 4 Oregon estimate was based on the area percentage of Zone 4, stratum 1 that is in Oregon times the density estimate generated for all of stratum 1 (Coos Bay to Patrick's Point, CA).

To compare density data across all years (1992 - 2008), strip transect surveys within 1250 meters of shore were used (since this is the area primarily surveyed in years prior to the Effectiveness Monitoring sampling design). The 3 regions of the coast used from 1992 to 1999 correspond exactly with Conservation Zone 3, stratum 1 (northern region), stratum 2 (central region), and the Oregon portion of Zone 4 (southern region). However, from 1996 to 1999 a subsample area in each region was used, with multiple replicates.

Shore Methods
To supplement age ratio productivity data, shore-based telescope surveys were conducted over 5 days in mid August. Location, elevation, field of view, duration of observations, and observing conditions were collected at each survey point. Survey points served as sample units. Group size, behavior, estimated distance from shore, molt, and age data were collected for Murrelets. Sum counts for all the other species were made as well.

RESULTS

NWFP Population Monitoring
During the population monitoring survey period between 15 May and 31 July we spent a total of 32 boat days conducting surveys at sea, during which 1,575 km of transects were conducted and 45 PSU transects were completed (Table 1). Thirty one PSU surveys were completed in Zone 3, and 14 in Zone 4 by CCR. RSL survey crew completed an 3 additional PSU surveys in southern Oregon (Table 1). One of the Zone 4 PSU completed by CCR was in California waters (PSU 10) as part of the cooperative effort with RSL.

The population estimate for Zone 3 was of 5,890 birds, 15% lower that the mean of estimates of other years (Table 2). This is consistent with the trend over all zones of continued slow decline (see Falxa et al. 2010). Stratum 1 (northern Oregon) contributed a higher proportion of the total than the prior two years, but was lower than all earlier years and showed a steeper decline than Stratum 2 (Fig.2).

Distribution and Abundance

The estimate for the Oregon portion of Zone 4 was of 2,806 birds, slightly above the long term average of 2,470 birds (Table 2). The state estimate, then, was of 8,696 birds with 95% confidence intervals from 5,680 to 12,405 birds (Table 2).

Using strip transect methods, near-shore murrelet densities were compared over the 17 year period 1992 – 2009 (Table 3). The downward trend of northern Oregon in the past 2 years was not evident in 2009, but this was largely due a high rate of detections at the south end of the region on one day (PSU 7 on 24 June, Table 1). Northern Oregon continued to have lower numbers relative to the first 7 years. Central and southern Oregon densities were more comparable with prior years (Table 3). Note that source data in Table 3 differs from that used in the population estimates (Table 2) in that it includes extra survey effort as well as near-shore PSU data, and different techniques (strip vs line transects) were used in generating densities.

Distribution of Marbled Murrelets was similar to prior years on a large geographic scale along the Oregon coast (Fig. 1). The 'stronghold' of the Oregon Marbled Murrelet population continues to be from the Alsea River to Coos Bay, offshore from the Siuslaw National Forest (Fig. 1). Highest oncentrations of murrelets were found on 21 and 22 July in PSU 11 and 12, respectively (Table 1).

The number of murrelet detections per km of transect made in the offshore subunit of PSU's in Zone 3 was higher than all prior years (Table 4). Though just 11.9% of detections per km were made in the offshore subunit (1500 m to 5000 m offshore) this was twice the average, and represents a significant contribution to the population estimate, since the offshore subunit makes up 81% of the population study area in Zone 3. A concentration of murrelets in the offshore subunit of PSU 14 on 29 May were foraging in the Siuslaw River plume. This one sample contributed disproportionately to the higher mean offshore distribution.

In Zone 4, 21.2 % of detections per km were made in the offshore subunit (2000 to 3000 m offshore). Zone 4 has typically shown a higher but more variable proportion of birds in the offshore subunit (Table 4). This region has a more variable bathymetry relative to shore, and has much less effort devoted to the smaller offshore survey area, which also increases variability.

Productivity

The first fledgling (Hatch Year; HY) Marbled Murrelet was recorded on 30 May 2009 in southern Oregon, south of Cape Arago. Features of age determination included fresh black and white plumage a distinct egg tooth seen in good light from 12 meters, and behavior typical of recently fledged juveniles (evasive diving). On 25 May a Marbled Murrelet with sharply black and white plumage was seen in central Oregon, but age determination was not made. Fledglings at sea were not seen after these anomalous May detections until July. HY detections became relatively frequent in the latter half of July. Using all aged murrelet data after 20 July (including those not on transect, see Strong 1996) to generate an index of productivity, we obtained a count of 36:757 HY to AHY (After Hatch-Year), or 4.54 % HY. Adding the shore based data from mid August (Appendix A) made the count 39:834 or 4.46% HY (Table 5). The sum density (total detections / total km of boat transect) of HY Marbled Murrelets in late July was 1.01 HY /km^2 in central Oregon, and 1.54 HY/ km^2 in southern Oregon (Table 6). Driving these relatively high densities were surveys on 30 and 31 July in which 10 and 13 HY were detected on transect, respectively (Table 1).

Common Murre HY became extremely common through July, with a mean density of 17.4 HY per km^2. This was much higher than the period 2005 – 2007, and comparable with densities of 2008 and earlier in the century (Table 6). Pigeon Guillemot fledgling densities of 0.59 HY/ km^2 in southern Oregon may reflect an early as well as successful nesting season for guillemots, since most nestlings usually fledge in August. August transects were not attempted in 2009.

Oceanographically, the summer of 2009 off the Oregon coast was neutral with respect to the large scale ENSO effects or regional anomalies. Bouts of strong northwest winds kept sea surface temperatures low, but with abrupt increases during periods of wind relaxation. Prey species identified in murre and murrelet beaks were either Osmerid smelt or sandlance (*Ammodytes hexapterus*). By June oceanographers determined that an El Nino was depressing the thermocline and moving east across the equatorial Pacific, but this had no effect on the California Current system. A crash in Anchovy and possibly other prey species in central California was reported, with impacts on cormorant nesting success and increased juvenile sea lion mortality (Pacific Seabird Group, Northcoast Marine Mammal center; pers. obs.) but there was no evidence of this in Oregon.

Methodology
The series of 10 distance estimation tests run for each observer at the start of survey days served as a check on their accuracy and for observers to calibrate their estimates. A total of 641 estimates were made by the 5 observers. Though some single observation estimates were off by –35% to +39%, The mean over the season for each observer ranged from –6.9% to -1.6%, and the overall mean for all observers was –4.1% (Std. Dev=18.8). This was the first year in which there was a net bias for observers to under estimate distances,

DISCUSSION

The 2009 Zone 3 population estimates in Oregon was 15% lower than the mean since the project began. This is consistent with the declining trend in overall population for the NWFP area (Zones 1 through 5) described by Falxa et al. (2010).

Northern Oregon densities (Stratum 1 of Zone 3) were up from the prior two seasons, but a large part of the contribution was from a single survey of PSU 7 in which 40% of all detections for the stratum were made (Table 1). I contend that these birds likely came from stratum 2 (PSU 8 or 9) and that the decline in northern Oregon continues to be severe, as seen in Fig. 2 and noted in Strong (2008).

Due the possibility of overestimation of density in Stratum 1 Zone 3 from above, and the higher contribution of the offshore subunit to the Stratum 2 estimate from a single PSU, there is the possibility the overall estimate for the zone is erroneously high. Further analysis could refine this, and additional years effort will clarify the trend.

In southern Oregon (Zone 4) it is important to point out that the population estimate of Table 2 is based on density of the entire Stratum 1 (which extends to Patrick's Point in California) as generated by the NWFP statistician (J. Baldwin). We know that there are consistent differences

in distribution within strata, and that the southern (California) PSU of this stratum typically have more detections. Thus the southern Oregon estimate is likely biased upwards and any trend pattern based on Table 2 data cannot be considered accurate. Another representation of Southern Oregon murrelet numbers is shown in Table 3, which is limited to Oregon waters and includes all nearshore transects (the 'Extra' transects of Table 1). Using these data, densities were14% lower than the 10 year average, comparable with Zone 3 results. Southern Oregon is geographically complex and a seasonal shift in distribution occurs in the area (Strong 1998), thus high within season and annual variability may be expected depending which PSU are sampled when.

This is the first year since the inception of NWFP monitoring in which line transect distance estimate trials showed a net bias to be conservative (underestimated) across all observers. This was unexpected and there is no clear explanation for it. The data are amenable to statistical analysis, but the significance of findings would remain in question since there is a difference between observer estimates of buoy targets in calm harbors (where estimation is usually done for feasibility) and those of murrelets at sea. Qualitatively, there is a clear bias at sea for observers to foreshorten estimates of distant birds (eg: over 75 m away) and a possible bias to exaggerate distance estimates of close birds (such as those within 15 m). Fortunately the distance program, and the typical murrelet detection functions generated by it, are robust with respect to these biases (ie; the critical features of the detection function lie between these extremes).

Indications of marine conditions point to 2009 as an above average year for seabird prey availability and production of young in Oregon. Oceanographically, annual California Current conditions have become more variable in recent years. Study of indicator species and trophic community patterns, along with modeling oceanographic parameters, has become an intense field of research as we attempt to understand the role of climate change and fisheries management on the near shore marine. The prevalence of osmerid smelt and sandlance in Oregon seabird diet may provide a 'buffer' against some fluctuation, since these prey are 'obligate' near shore species and are not targeted commercially.

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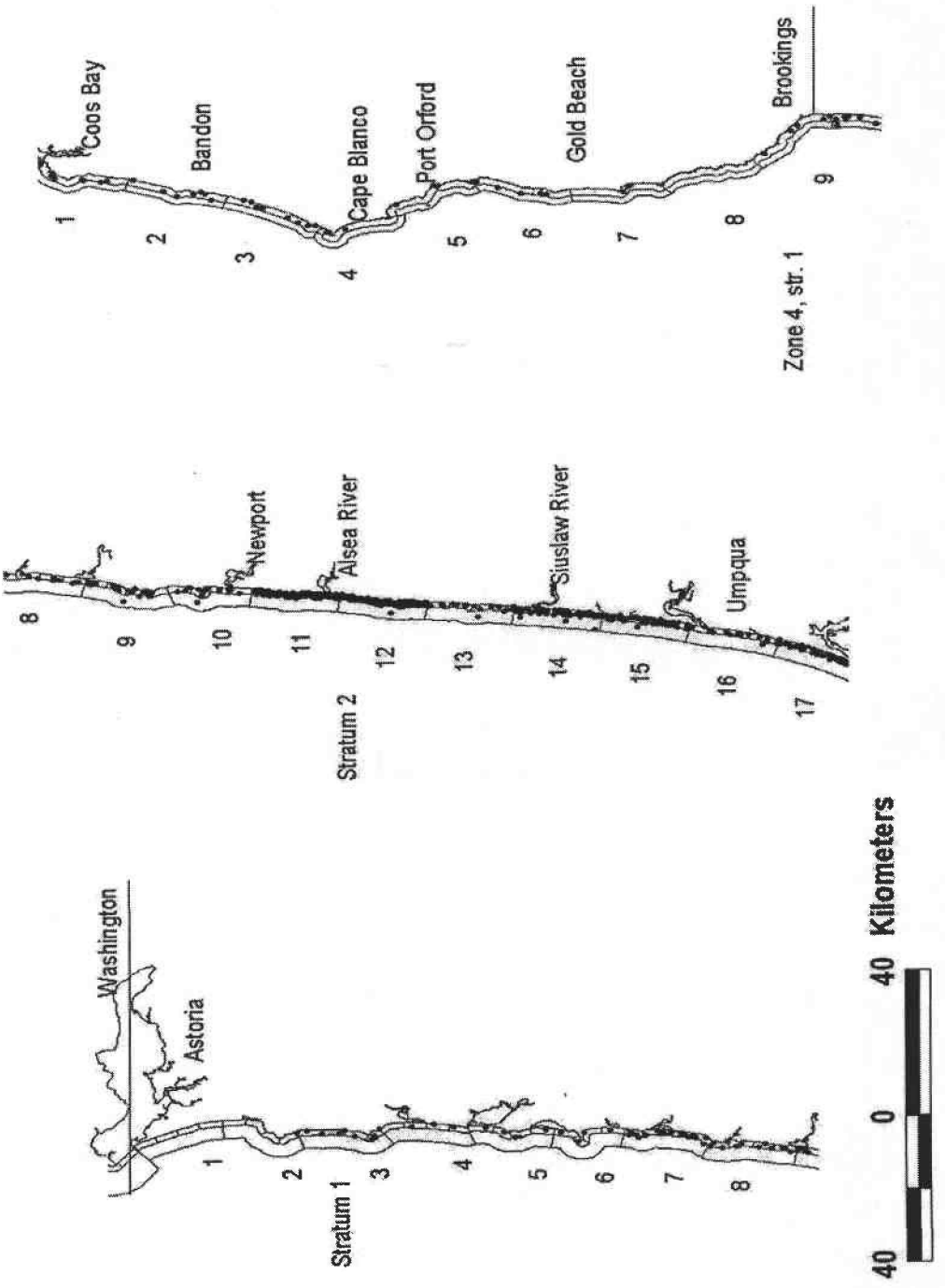

Figure 1. The Oregon coast divided by Conservation Zone strata showing PSU locations by number. Dots represent the mean number of Marbled Murrelet detections from PSU samples during 2009.

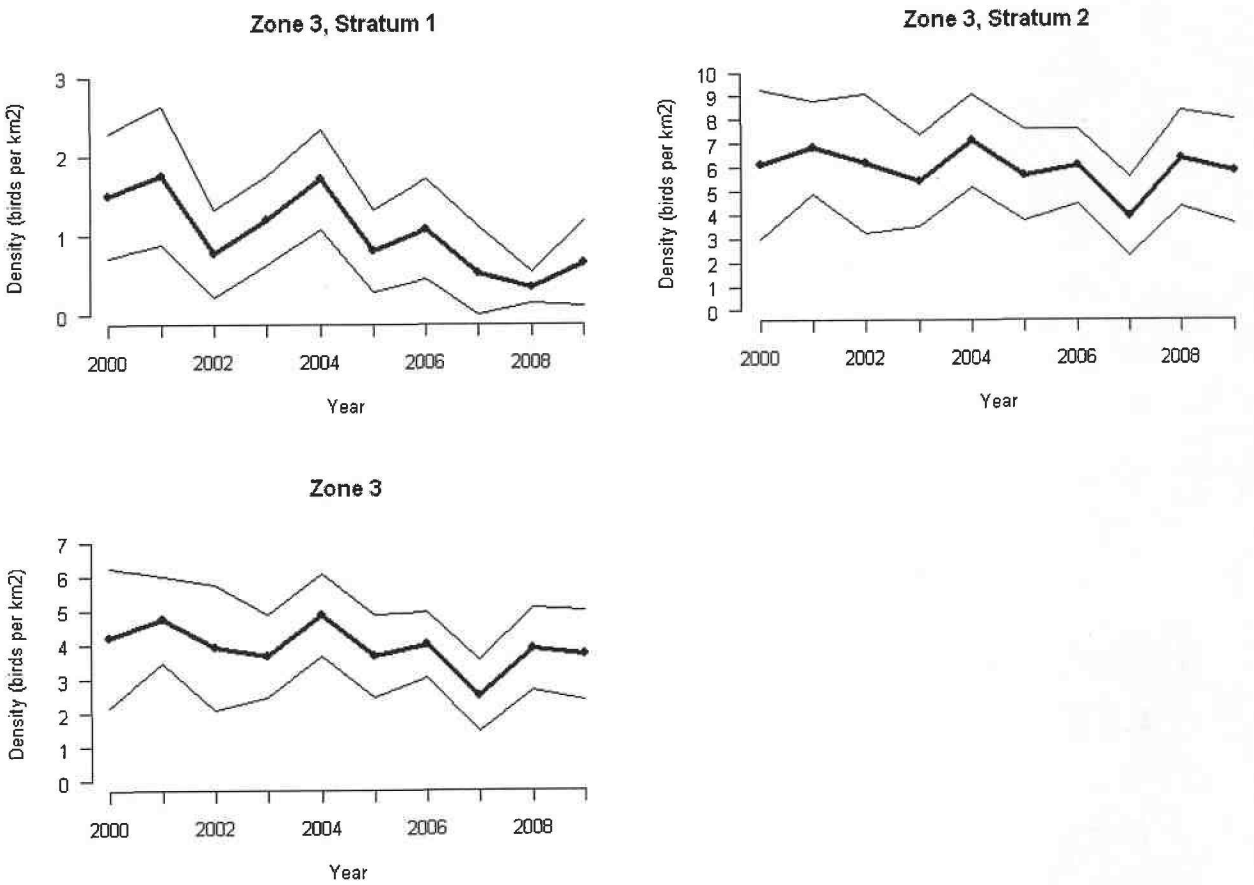

Figure 2. Estimates of Marbled Murrelet density and 95% confidence intervals in the northern (1) and southern (2) strata of Conservation Zone 3, and combined over the study period 2000 – 2009. Figure courtesy of Jim Baldwin (USFS PSW Station, Albany, CA).

Table 1. Summary of survey effort (Km.) and number of murrelet detections (Det.) for all boat days during 2009. Inshore and Offshore refer to subunits of PSU samples, Extra are transects conducted in addition to the PSU transect effort. In parentheses is the number of HY fledglings counted. Refer to Figure 1 for PSU locations.

			Inshore		Offshore		Extra		DAY TOTAL	
Date	Zone	PSU	Km	Det.	Km	Det.	Km	Det.	Km	Det.
May 16	3	10	18.1	7	15.7	1			33.8	10
17	3	7	20.1	9	24.7	3				
17	3	8	21.2	13	8.5	0			74.5	25
18	3	11	20.0	34	17.1	0			37.1	34
19	3	15	20.0	23	17.2	2	10.0	24		
19	3	16	20.0	1	13.5	0	12.0	0	92.7	50
25	3	9	19.9	22	14.0	4	5.0	73	38.9	99
27	3	5	20.9	2	18.2	0	7.5	3	46.6	5
28	3	3	20.1	4	17.7	1	5.8	0	43.6	5
29	3	13	20.1	12	17.2	4				
29	3	14	20.3	34	17.2	29	8.5	59	83.3	122
30	4	1	20.0	12(1)	6.2	0			26.2	12(1)
June 3	3	11					18.8	60	18.8	60
3	3	12	20.3	49	17.2	9	2.5	13	58.8	131
3	4	9 (RSL)	20.7	16	6.1	0				
3	4	8 (RSL)	20.3	2	6.0	0			53.1	18
4	4	5 (RSL)	21.0	6	5.6	0			26.6	6
4	4	3	20.2	4	5.9	0				
4	4	4	20.1	8	6.0	0			52.3	12
6	4	6	20.4	9	6.0	5				
6	4	7	20.4	7	6.0	0			52.8	21
7	3	17	19.9	33	17.3	2	5.0	15	42.2	47
10	3	10	21.1	18	13.6	1			34.7	19
12	3	9	19.9	8	16.6	0			36.5	8
16	3	15	19.9	52	17.1	1				
16	3	16	20.0	17	17.2	4	5	3	80.2	81
17	4	2	19.0	8	6.1	0	7.9	3	33.0	11
19	3	1	21.5	0	15.0	0			36.5	0
24	3	6	21.5	2	16.6	0				
24	3	7	16.2	21	15.0	0			69.3	23
July 9	3	13	20.0	20	14.0	0				
9	3	14	20.0	46(1)	17.2	4			37.2	46(1)
10	4	10	20.2	27	5.9	3	4.9	0	30.8	30
12	4	5	20.9	12	5.7	0				
12	4	6	20.6	18	6.0	2			53.2	32
13	3	8	20.2	8	13.8	1			34.0	9
17	3	2	20.5	0	18.0	0				
17	3	3	19.6	7	14.7	0			72.8	7
18	3	4	19.5	2	12.7	0				
18	3	5	20.4	1	14.5	0			67.1	3
21	3	11	20.4	114(2)	16.1	1			36.5	115(2)
22	3	12	20.2	113(1)	12.9	0			33.1	113(1)
24	4	9	20.5	13	5.2	2			25.7	15
27	4	7	20.1	7	5.7	0			25.8	7
28	3	10	20.4	12	12.8	0			33.2	12
30	3	17	19.7	30(8)	16.2	0				
30	4	1	20.9	23(2)	6.1	0	2.7	1	65.8	50(10)
31	4	2	19.1	35(7)	6.1	0	3.2	10(4)		
31	4	3	20.1	19(2)	6.1	1(1)			54.6	65(14)
TOTAL ZONE 3 STR 1			200.7	48(0)	167.1	4(0)	13.3	3(0)	381.1	55
TOTAL ZONE 3 STR 2			421.6	666(12)	322.4	63(0)	66.8	247(0)	810.8	976
TOTAL ZONE 4 STR 1			343.9	226(12)	100.7	13(1)	18.7	14(4)	463.3	253
SEASON TOTAL			904.2	916(24)	572.5	80(1)	98.8	264(4)	1,655.2	1,284(29)

Table 2. Marbled Murrelet estimates of density and population size in Conservation Zone 3 and the Oregon portion of Zone 4 from 2000 to 2009, using line transect analysis from the NWFP (J. Baldwin). Statewide estimates are area-weighted. Statewide error terms are not available.

Year	Region	Density	Std. error	Population Est.	95% C I
2000	Zone 3 Stratum 1	1.501	0.390	992	496 - 1,527
	Stratum 2	6.134	1.569	5,732	3,227 - 8,746
	Zone 4. Oregon	6.015	2.022	2,900	2,100 - 5,800
	STATE TOTAL	4.70	-	9,600	5,800 - 16,200
2001	Zone 3 Stratum 1	1.745	0.433	1,153	613 - 1,712
	Stratum 2	6.832	0.982	6,385	4,294 – 8,012
		4.635	1.212	2,200	1,600 - 4,000
	STATE TOTAL	4.74	-	9,600	5,600 - 13,600
2002	Zone 3 Stratum 1	0.764	0.275	505	262 – 991
	Stratum 2	6.170	1.464	5,767	3,514 - 9,166
	Zone 4. Oregon	5.219	0.761	2,500	1,700 - 3,300
	STATE TOTAL	4.29	-	8,800	5,600 - 13,400
2003	Zone 3 Stratum 1	1.191	0.279	787	492 - 1,167
	Stratum 2	5.435	0.962	5,079	3,237 - 6,637
	Zone 4. Oregon	5.024	1.027	2,652	1,821 - 3,959
	STATE TOTAL	4.037	-	8,508	5,541 - 11,828
2004	Zone 3 Stratum 1	1.707	0.313	1,128	706 - 1,599
	Stratum 2	7.119	0.981	6,653	4,833 - 8,443
	Zone 4. Oregon	4.323	2.129	2,073	1,289 - 5,080
	STATE TOTAL	4.791	-	9,859	6,463 - 15,297
2005	Zone 3 Stratum 1	0.812	0.259	537	273 – 943
	Stratum 2	5.678	0.972	5,306	3,170 -6,703
	Zone 4. Oregon	4.452	1.117	2,134	1,448 -3,547
	STATE TOTAL	3.845	-	7,977	4,891 - 11,193
2006	Zone 3 Stratum 1	1.082	0.319	715	335 – 1,174
	Stratum 2	6.056	0.780	5,659	3,927 – 6,707
	Zone 4. Oregon	4.840	0.759	2,320	1,787 – 3,205
	STATE TOTAL	4.190	-	8,694	6,049 – 11,086
2007	Zone 3 Stratum 1	0.520	0.300	343	21 – 698
	Stratum 2	3.909	0.829	3,653	2,459 – 5,555
	Zone 4. Oregon	4.790	1.405	2,294	1,535 – 4,167
	STATE TOTAL	3.033	-	6,290	5,330 – 12,611
2008	Zone 3 Stratum 1	0.346	0.096	229	106 – 350
	Stratum 2	6.364	1.015	5,948	3,876 – 7,658
	Zone 4. Oregon	5.869	1.254	2,814	2,036 – 4,313
	STATE TOTAL	4.334	-	8,991	6,018 – 12,321
2009	Zone 3 Stratum 1	0.649	0.268	429	191 – 867
	Stratum 2	5.844	1.097	5,461	3,501 – 7,408
	Zone 4. Oregon	5.854	1.154	2,806	1,988 – 4,130
	STATE TOTAL	3.806	-	8,696	5,680 – 12,405

Table 4. A comparison of Marbled Murrelet detections per km of survey effort in the inshore versus offshore subunits of PSU surveys from 2000 to 2008 by Conservation Zone.

Year	Zone 3 Detections / km (% of inshore)		Zone 4 (OR) Detections / km (% of inshore)	
	Inshore (300-1500)	Offshore (1500-5000)	Inshore (350-2000)	Offshore (2000-3000)
2000	0.921	0.071 (7.7)	0.500	0.194 (38.8)
2001	1.328	0.063 (4.7)	0.913	0.091 (10.0)
2002	1.116	0.057 (5.1)	0.719	0.083 (11.5)
2003	1.460	0.048 (3.3)	0.852	0.037 (4.3)
2004	1.721	0.062 (3.6)	0.478	0.076 (15.9)
2005	0.987	0.051 (5.2)	0.532	0.018 (3.4)
2006	1.193	0.068 (5.7)	0.545	0.128 (23.5)
2007	1.218	0.056 (4.6)	0.650	0.217 (33.4)
2008	1.497	0.099 (6.6)	0.623	0.129 (20.1)
2009	1.147	0.137 (11.9)	0.657	0.139 (21.2)
Average	1.259	0.071 (5.6)	0.647	0.111 (17.2)

Table 5. Number of after hatch year (AHY) and hatch year fledgling (HY) Marbled Murrelets and percent HY for 3 regions of the Oregon coast. Data include all aged birds after 20 July, 1992 to 2009. 2004, 2006 and 2009 data include shore observations.

Year	Northern		Central		Southern		State total	
	HY/AHY	(%HY)	HY/AHY	(%HY)	HY/AHY	(%HY)	HY/AHY	(%HY)
1992	7/99	(6.60)	70/2229	(3.04)	20/967	(2.03)	97/3295	(2.86)
1993	7/441	(1.56)	16/1606	(0.99)	No data		23/2047	(1.11)
1994	6/119	(5.04)	23/883	(2.54)	19/555	(3.31)	48/1557	(2.99)
1995	14/100	(12.28)	33/1199	(2.68)	33/728	(4.34)	80/2027	(3.80)
1996	7/91	(7.14)	62/2343	(2.58)	22/716	(2.98)	91/3150	(2.81)
1997	4/51	(7.27)	26/1265	(2.01)	17/340	(4.76)	47/1656	(2.76)
1998	9/93	(8.82)	30/1500	(1.96)	11/440	(2.44)	50/2033	(2.40)
1999	7/79	(8.14)	38/1522	(2.44)	20/639	(3.03)	65/2240	(2.82)
2000	3/49	(5.77)	54/702	(7.14)	29/232	(11.55)	86/983	(8.04)
2001*	2/111	(1.77)	44/1110	(3.81)	23/331	(6.52)	69/1552	(4.26)
2002	11/49	(18.33)	14/277	(4.81)	5/104	(4.59)	30/430	(6.52)
2003	5/51	(8.93)	23/658	(3.33)	14/155	(8.28)	42/864	(4.64)
2004	1/50	(1.96)	14/528	(2.57)	5/190	(2.56)	20/768	(2.54)
2005	No data		No data		No data		-	
2006	2/48	(4.00)	10/59	(1.76)	24/309	(7.21)	36/916	(3.78)
2007	No data		8/282	(2.76)	31/331	(8.56)	39/652	(5.98)
2008	1/3 (No data)		22/899	(2.39)	8/99	(7.48)	30/1001	(3.00)
2009	0/4 (No data)		14/538	(2.54)	17/224	(7.05)	31/765	(3.90)

* Including all data after 10 July.

Table 6. Strip transect density of fledgling (HY) Alcids and HY/AHY productivity indices from all surveys after 19 July 2000 to 2009. Km = kilometers of transect

ZONE 3		Common Murre		Marbled Murrelet		Pigeon Guillemot		Rhinoceros Auklet	
Year	Km	Density	Ratio	Density	Ratio	Density	Ratio	Density	Ratio
2000	901	26.05	0.262	0.60	0.085	0.42	0.137	0.17	0.101
2001	856	23.60	0.218	0.34	0.031	0.35	0.093	0.08	0.049
2002	520	13.48	0.218	0.46	0.095	0.37	0.089	0.06	0.051
2003	402	15.87	0.092	0.52	0.050	0.37	0.070	0.07	0.091
2004	273	21.76	0.316	1.25	0.084	0.44	0.069	0.07	0.021
2005*	78	4.49	0.062	0.00	0.000	0.00	0.000	0.00	0.000
2006	367	4.25	0.107	0.33	0.032	0.19	0.046	0.00	0.000
2007	214	4.35	0.037	0.84	0.083	0.61	0.076	0.00	0.000
2008*	375	10.03	0.093	0.67	0.027	0.13	0.049	0.00	0.000
2009*	139	29.28	0.127	1.01	0.024	0.00	0.000	0.22	0.136
Sum	4,125								
Weighted avg.		17.86	0.185	0.56	0.058	0.34	0.084	0.08	0.075
ZONE 4									
2000	182	8.24	0.437	1.54	0.143	1.15	0.147	0.60	0.149
2001	190	24.53	0.369	0.74	0.065	0.32	0.105	0.11	0.038
2002	78	37.31	0.402	0.64	0.067	1.28	0.067	0.51	0.027
2003*	70	11.00	0.199	1.00	0.086	0.29	0.039	0.00	0.000
2004	93	18.17	0.191	0.22	0.024	0.86	0.070	0.22	0.017
2006	117	3.16	0.091	1.28	0.114	0.09	0.014	0.00	0.000
2007	85	2.00	0.098	2.47	0.098	0.94	0.103	0.12	0.167
2008*	148	24.59	0.210	0.41	0.077	0.61	0.188	0.00	0.000
2009*	136	10.51	0.245	1.54	0.080	0.59	0.129	0.44	0.231
Sum	1,099								
Weighted avg.		15.60	0.270	1.08	0.087	0.66	0.110	0.24	0.076

* Does not include August survey effort.